NANOSKIN® FOR MEDICAL APPLICATIONS

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Abstract

The present paper describes Nanoskin® production for medical applications. Nanoskin® is produced from the bionanotechnology process. Nanoskin® is a highly hydrated pellicle made up of a random assembly of ribbon shaped fibers less than 100 nm wide. These fibers themselves are composed of a bundle of much finer micro fibrils of nanometric size. In the medical field, it's worth highlighting its application as a temporary skin substitute in the treatment of burns and wounds of difficult healing. New Nanoskin® nanocomposite material is an osteoinductor or be stimulates the bone regeneration, enabling bigger migration of the cells for formation of the bone fabric and for osteoporosis treatment. In addition, Nanoskin® membrane is used for: Drug Delivery, Stent covering to avoid re-stenosis and, for replacing of Dura Mater and intervertebral disc, Ophthalmologic prostheses, Scaffolds for organs cultures and Diabetic injury. Another advantage, the Nanoskin® dressing reduces the treatment time and thereby reduces the cost of hospitalization of patients with burns or chronic wounds. Nanoskin is expected to be a new biodegradable bionanopolymer.

Keywords: Nanoskin®, bacterial cellulose, nanocomposites, bone regeneration, osteoporosis treatment.

1 INTRODUCTION

Recent advances in the field of natural materials and their medical applications indicate the significance and potential of various nanobiocellulose in the development of novel classes of medical devices and applications in healthcare and veterinary medicine. Natural based polymers have been applied in tissue engineering as scaffolds in order to provide an appropriate environment to the growth and differentiation of cells.

The ideal scaffold requires a desirable mechanical rigidity and a porous 3D structure which can provide maximum integration with cells and body fluids, plus have a nanostructure surface which facilitates the adhesion of cells [1]. In tissue engineering, matrices are developed to support cells, promoting their differentiation and proliferation towards the formation of a new tissue. Such strategies allow for producing hybrid constructs that can be implanted in patients to induce the regeneration of tissues or replace failing or malfunctioning organs. Natural based polymers offer the advantage of being similar to biological macromolecules, which the biological environment is prepared to recognize and deal with metabolically. Owing to their similarity with the extracellular matrix (ECM), natural polymers may also avoid the stimulation of chronic inflammation or immunological reactions and toxicity, often detected with synthetic polymers [2]. Bacterial cellulose (BC) has established to be a remarkably versatile biomaterial and can be used in wide variety of applied scientific Endeavour's. Due to its unique nanostructure and properties, microbial cellulose is a natural candidate for numerous medical and tissue-engineered applications. Moreover, the nanostructure and morphological similarities with collagen make BC attractive for cell immobilization and cell support [3-5].

Nanoskin® is a highly hydrated pellicle made up of a random assembly of ribbon shaped fibers less than 100 nm wide. These fibers themselves are composed of a bundle of much finer micro fibrils of nanometric size. The unique properties provided by the nanometric structure have lead to a number of diagnostic biological probes, display devices [6-7] due to their unique size-dependent optical, electrical and magnetic properties, and medical applications including biological tissue use as temporary human skin substitute in wounds such as burns, traumatic wounds, chronic ulcers, and wounds in diabetic patients. In contrast, the benefits included immediate pain relief, close adhesion to the wound bed, diminished post surgery discomfort and reduced infection rate. The transparent nanobiocellulose made wound inspection easy while Nanoskin® detached when new skin formed. By reducing treatment time and costs, Nanoskin® has potentially financial viability.

2 EXPERIMENTAL DETAILS

2.1 Synthesis of Bacterial Cellulose

Nanoskin® bacterial cellulose (BC) produced by Gram-negative acetic acid bacteria Gluconacetobacter xylinus can be obtained from the culture medium in the pure 3-D structure consisting of an ultra fine network of cellulose nanofibres (3–8 nm), highly hydrated (99% in weight), and displaying higher molecular weight, higher cellulose crystallinity (60-90%), enormous mechanical strength and full biocompatibility [8].

2.2 Bionanocomposites characterization

Scanning Electron Microscopy (SEM)- Scanning electronic microscopy and Transmission electron microscopy (TEM) images were performed on a PHILIPS. The samples were covered with gold and silver paint for electrical contact and to perform the necessary images.

3 Results and Discussion

3.1 Scanning Electronic Microscopy (SEM) and Transmission electron microscopy (TEM)

Nanoskin® mats were characterized by SEM and TEM. Fig. 1(a,b) shows respectively, as an example, SEM and TEM image of Nanoskin® surface morphology formation.

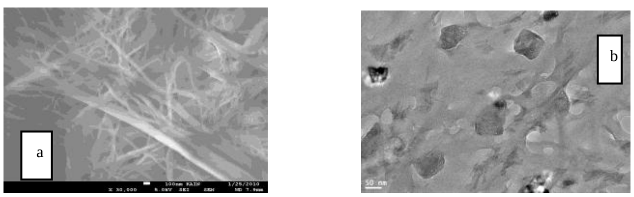

Fig.1. a) Nanoskin® Scanning electron microscopy (SEM); b) Nanoskin® Transmission electron microscopy (TEM) images .

3.2 Nanoskin® in the Treatment of Chronic Wounds and Burns

Burns are very complex injuries, causing extensive damage to skin tissues. The healing process involves the regeneration of the epidermis and the repair of the dermis, both of which result in the formation of scar tissue [9]. The major goal during treatment of burn patients is to quickly accomplish effective wound closure to increase the rate of healing and significantly reduce pain [10-11]. In addition, proper wound management must prohibit the wound from becoming infected and dehydrated [12] . Despite the fact that many different biological and synthetic wound dressings have already been developed, we conclude that Nanoskin® is virtually the only product that encompasses all qualifications desired. Because of its unique properties, nanobiocellulose has been shown to be a highly effective wound dressing material. In fact, the results of burns, wound naturopathic (Hansen), healing process can be show in figure 2. (a, and b) respectively.

a)

b)

Fig.2. a) burns second degree, after 7 days was completely healing. (b) ; show a Patient 87 years old with Diabetic naturopathic (Hansen), it was took 3 months to obtained satisfied results.

Nanoskin® was very effective in promoting autolytic debridement, reducing pain, and accelerating granulation, all of which are important for proper wound healing. These Nanoskin® membranes can be created in any shape and size, which is beneficial for the treatment of large and difficult to cover areas of the body. Nanoskin® it has also been used in a wide range of medical applications such as: Dura mater substitute due to the highly resistant and flexible and biocompatible and absorbable, In vertebral disc prosthesis and bones, and like Nanoskin® Nanosten which can reduce rest enosis and prevents thrombosis.

3.3 Nanoskin® membranes in Tissue Engineering and Nanobiocomposite

Tissue engineering is applied science that uses knowledge of biology, biochemistry and biophysics to develop artificial tissues, such as epithelial tissues, cartilage and bone. Tissues can be produced from the cultivation of cells in vitro with the use of certain biodegradable substrates. Drug delivery systems, often described as "drug-delivery systems, offer many qualities when compared to other conventional systems because this system will produce more effective treatment, due to the controlled release of drug from the matrix degradation .

The Nanoskin® has characteristics that justify their use. The chemical groups (OH) found in the structure of Nanoskin® can serve as supports for incorporation of drugs. The release rate can be controlled depending on the size of the particles and their hydration; the particles can reach nanometric orders.

In this context, metal nanoparticles has been produced by colloidal synthesis with amino acids, like Cysteine and Methionine, and its incorporation studied in a nanobiocellulose by the process of electro spraying and casting films for biomedical applications.

Basmaji et al produce a nanocomposite with antimicrobial properties and angiogenic properties just immersed a Nanoskin® (BC) pellicle in latex from natural rubber/silver nanoparticles solution[13].In addition, we obtained also conducting paper just immersed a Nanoskin® (BC) pellicle in multi walled carbon nanotube solution[14] . Carbon nanotube distribution in Nanoskin® bacterial cellulose was uniform and essential for sensor applications. Figure 3 illustrated SEM images of Nanoskin®/carbon nanotubes nanocomposites.

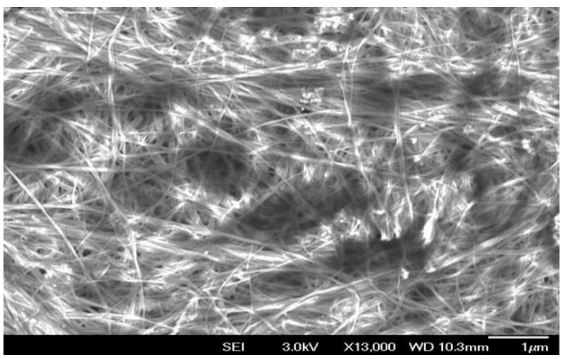

Fig.3- SEM images of Nanoskin®/carbon nanotubes nanocomposites

As a result the mechanical properties of the nanocomposites differed from those of the pure silk protein or bacterial cellulose films. In the dry state, the tensile modulus of the composite film (465 ± 57 MPa) was higher than that of the neat BC film (118 ± 9 MPa) or silk fibroin film (355 ± 56 MPa). However the composite films were more brittle than the silk fibroin film. On the other hand, in the hydrated state, the composite was tougher and more flexible with an elongation at break reaching 13.5 ± 2.9% but exhibited very low tensile strength and modulus.

Recently,we report the first Nanoskin®/ otoliths / collagen nanocomposites as a potential scaffold for bone regeneration and natural transdermal patch for osteoporosis treatment[15-17].

Nanoskin® nanocomposite biomaterial is an osteoinductor or be stimulates the bone regeneration, enabling bigger migration of the cells for formation of the bone fabric. The biomaterial is constituted of some elements constituents of the bones, as collagen (protein) and nano-otoliths, beyond the membrane of Nanoskin® (BC). Collagen is regarded by many as an ideal scaffold or matrix for tissue engineering as it is the major protein component of the extracellular matrix, providing support to connective tissues such as skin, tendons, bones, cartilage, blood vessels, and ligaments [18-19]. In its native environment, collagen interacts with cells in connective tissues and transduces essential signals for the regulation of cell anchorage, migration, proliferation, differentiation, and survival [19-20]. Collagen scaffolds, due to their fast degradation, do not allow isomorphous replacement with a newly formed bone. Presumably, due to the stable macro porous structure and slow degradation, the progression and extent of osteogenesis were markedly and significantly higher for silk and RGD–silk scaffolds when compared with collagen scaffolds [20].

In vivo analysis shows bone surface tissue with high regularity, higher osteoblast activity and osteo-reabsorption activities areas. The detail of experimental conditions was already reported by Basmaji et al [14-16]. These findings indicate that our novel Nanoskin® nanocomposite delivery system is a promising approach to improve compliance and quality of life of patients in the treatment of bone diseases.

4 CONCLUSION

Nanoskin® has been used in different areas of medicine as: substitute of blood vessels and linfatics, on lesions of tegument (serious burns, skin graft in the donor and receiving areas), facial peeling, infectious dermolysis, abrasion of tattoos chronic ulcers, Hanseníase of the distal members.

Experimental studies for clinical application have been accomplished with Nanoskin® membrane in several conditions as: protective cover for reconstruction of nerves; duraplasty; healing of epithelial lesions of cornea; healing of duodenal lesions; substitute of blood vessels; cuffs for of reconstruction of micronerves; reconstruction of the retroperitoneum; and technical training in microsurgery.

In summary, the Nanoskin® dressing advantage is reduces the treatment time and thereby reduces the cost of hospitalization of patients with burns or chronic wounds. Nanoskin® nanocomposite biomaterial as a potential scaffold for bone regeneration should be designed for different applications, such as: to induce vascularization; facilitate the deposition of otoliths in predefined regions; guide the regeneration of tissue in certain directions permit the development of different tissues ; or inhibit calcification and cell adhesion ; BC is a good candidate for site-specific drug delivery. These multiform aspects of BC indicate that its potential applications in the medical and pharmaceutical field.

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